CSE 331
Software Design and Implementation

Lecture 22
System Development

Leah Perlmutter / Summer 2018

Announcements

Announcements

- Last Friday's Guest Speaker (Kendra Yourtee)
  - Sign thank-you card
  - Take survey: https://tinyurl.com/yay8m24s
- Campus Maps Demos Wednesday!
  - You don't have to be finished with HW9
  - The first 10 volunteers will receive a special reward
  - Sign up here: https://tinyurl.com/yay092374
- Course evaluations – Please give feedback on this course!
  - You should have received an email from "UW Course Evaluations" with the link
  - https://uw.iasystem.org/survey/195871

Announcements

- Quiz 8 due Thursday 8/16
- Homework 9 due Thursday 8/16
- Final Exam Friday in class (60 minutes)
  - Covers all material after the midterm
  - Final exam review: during section Thursday 8/16

System Development

Context

CSE331 is almost over…

- Focus on software design, specification, testing, and implementation
  - Absolutely *necessary* stuff for any nontrivial project
- But *not sufficient* for the real world: At least 2 key missing pieces
  - Techniques for larger systems and development teams
    - This lecture; yes fair game for final exam
    - Major focus of CSE403 (Software Engineering)
  - Usability: interfaces engineered for humans
    - Another lecture: didn't fit this quarter
    - Major focus of CSE440 (HCI)

Outline

- Software architecture
- Tools
  - For build management
  - For version control
  - For bug tracking
- Scheduling
- Implementation and testing order

Software Architecture

Architecture

Software architecture refers to the high-level structure of a software system

- A principled approach to partitioning the modules and controlling dependencies and data flow among the modules

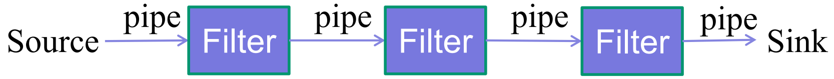
Common architectures have well-known names and well-known advantages/disadvantages

A good architecture ensures:

- Work can proceed in parallel
- Progress can be closely monitored
- The parts combine to provide the desired functionality

Example architectures

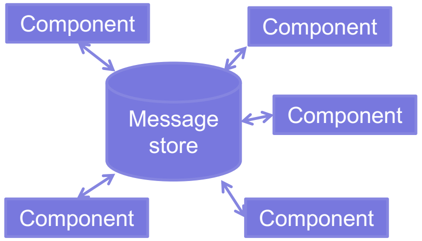
Pipe-and-filter (think: iterators)



Source pipe Filter pipe Filter pipe Filter pipe Sink

Blackboard

(think: callbacks)



Component
Component
Message store
Component
Component
Component

Layered

(think: levels of abstraction)

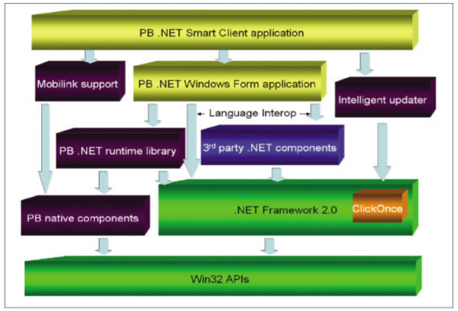


FIGURE 1 | ARCHITECTURAL DIAGRAM OF A POWERBUILDER SMART CLIENT APPLICATION

A good architecture allows:

- Scaling to support large numbers of ______
- Adding and changing features
- Integration of acquired components
- Communication with other software
- Easy customization
  - Ideally with no programming
  - Turning users into programmers is good
- Software to be embedded within a larger system
- Recovery from wrong decisions
  - About technology
  - About markets

System architecture

- Have one!
- Subject it to serious scrutiny
  - At relatively high level of abstraction
  - Basically lays down communication protocols
- Strive for simplicity
  - Flat is good
  - Know when to say no
  - A good architecture rules things out
- Reusable components should be a design goal
  - Software is capital
  - This will not happen by accident
  - May compete with other goals the organization behind the project has (but less so in the global view and long-term)

Temptations to avoid

- Avoid featuritis
  - Costs under-estimated
    - Effects of scale discounted
  - Benefits over-estimated
    - A Swiss Army knife is rarely the right tool
- Avoid digressions
  - Infrastructure
  - Premature tuning
    - Often addresses the wrong problem
- Avoid quantum leaps
  - Occasionally, great leaps forward
  - More often, into the abyss

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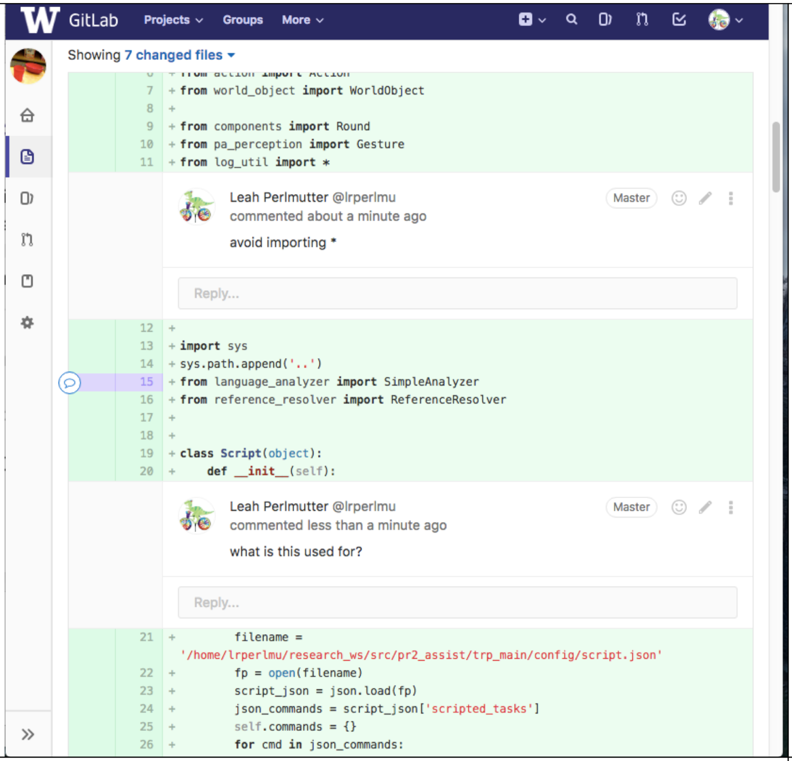
Tools

Build tools

- Building software requires many tools:
  - Java compiler, C/C++ compiler, GUI builder, Device driver build tool, InstallShield, Web server, Database, scripting language for build automation, parser generator, test generator, test harness
- Reproducibility is essential
- System may run on multiple devices
  - Each has its own build tools
- Everyone needs to have the same toolset!
  - Wrong or missing tool can drastically reduce productivity
- Hard to switch tools in mid-project

If you're doing work the computer could do for you,
then you're probably doing it wrong

Code Review



Showing 7 changed files

```
+ from action import Action
+ from world_object import WorldObject
+
+ from components import Round
+ from pa_perception import Gesture
+ from log_util import *
```

Leah Perlmutter @lrperlmu
commented about a minute ago
avoid importing *

```
+
+ import sys
+ sys.path.append('..')
+ from language_analyzer import SimpleAnalyzer
+ from reference_resolver import ReferenceResolver
+
+
+ class Script(object):
+     def __init__(self):
```

Leah Perlmutter @lrperlmu
commented less than a minute ago
what is this used for?

```
+         filename =
'/home/lrperlmu/research_ws/src/pr2_assist/trp_main/config/script.json'
+         fp = open(filename)
+         script_json = json.load(fp)
+         json_commands = script_json['scripted_tasks']
+         self.commands = {}
+         for cmd in json_commands:
```

Version control (source code control)

- A version control system lets you:
  - Collect work (code, documents) from all team members
  - Synchronize team members to current source
  - Have multiple teams make progress in parallel
  - Manage multiple versions, releases of the software
  - Identify regressions more easily
- Example tools:
  - Subversion (SVN), Mercurial (Hg), Git
- Policies are even more important
  - When to check in, when to update, when to branch and merge, how builds are done
  - Policies need to change to match the state of the project
- Always diff before you commit

Issue tracking

- An issue tracking system supports:
  - The team’s to-do list
    - who will do each work item and when
  - Tracking and fixing bugs and regressions
  - Communicating among team members

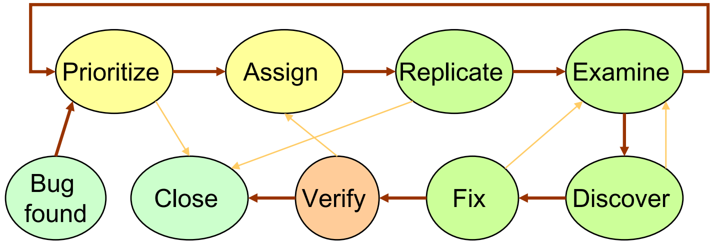
- Essential for any non-small or non-short project

- Example tools:
  - cloud hosted: Google Developers, GitLab, GitHub, Bitbucket, Jira, Trello
  - host your own: Bugzilla, Flyspray, Trac

Issue tracking

Need to configure the bug tracking system to match the project
- Many configurations can be too complex to be useful

A good process is key to managing bugs
- An explicit policy that everyone knows, follows, and believes in


Prioritize
Assign
Replicate
Examine
Bug found
Close
Verify
Fix
Discover

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Scheduling and Scoping

Scheduling and Scoping

"More software projects have gone awry for lack of calendar time than for all other causes combined."
-- Fred Brooks, *The Mythical Man-Month*

Three central questions of the software business
3. When will it be done?
2. How much will it cost?
1. When will it be done?

- Estimates are almost always too optimistic
- Estimates reflect what one wishes to be true
- We confuse effort with progress
- Progress is poorly monitored
- Slippage is not aggressively treated

Some wry wisdom...

A project expands to fill up the time you have available for it.

Hofstadter's Law: It always takes longer than you expect, even when you take into account Hofstadter's Law.

SMART goals

The name is cheesy, but it’s a valuable concept
Specific
Measurable*****
Achievable
Relevant
Timebound*****

- Work on HW9
  - when? how much work?
- Work on HW9 by 5pm on Wednesday 8/15
  - how much work?
- Get HW9 mostly done by 5pm on Wednesday 8/15
  - what does “mostly done” mean?
- Get HW9 completely done by 5pm on Thursday 8/16

Milestones in a Software Project

- Milestones are critical keep the project on track
  - Policies may change at major milestones
  - Check-in rules, build process, etc.

- Some typical milestones (names)
  - Design complete
  - Interfaces complete / feature complete
  - Code complete / code freeze
  - Alpha release
  - Beta release
  - Release candidate (RC)
  - FCS (First Commercial Shipment) release

Effort is not the same as progress

Effort is the amount of time spent earnestly working on the project
  - Can be equated with number of hours
  - Cost of the project (salary paid to workers) is proportional to effort

Progress involves reaching milestones
  - Hard to track, because it is hard to make good milestones

- Often lots of effort leads to little progress
  - This is normal! Much experience gained!
    - but for some reason, managers don’t seem to like it
      - (see cost)
  - Be honest with yourself.
    - You can’t just “catch up before anyone notices”
  - Need to adjust the schedule

When you know you will miss a milestone...

Change the scope and/or the due date.

- Option A: Later deadline, same amount of work
- Option B: Same deadline, less work
- Option C: Same deadline, same amount of work
- Option D: Later deadline, and more work

- Which of these will set you up for success?
  - only A and B.
- Options C and D are implemented surprisingly frequently, often with painful results.

Dealing with slippage

- People must be held accountable
  - Slippage is not inevitable
  - Software should be on time, on budget, and on function

- Four options
  - Add people – startup cost (“*mythical man-month*”)
  - Buy components – hard in mid-stream
  - Change deliverables – customer must approve
  - Change schedule – customer must approve

- Take no small slips
  - One big adjustment is better than three small ones

It’s a learning process!

- Scoping and time management, like other skills, can be learned!
- Delivering stuff late just means you have not yet learned good time managment (growth potential!)
  - might have consequences, but not the end of the world
- Make sure to change your process for the next time

- Retrospective – discussing/analyzing past work in order to learn how to improve your (team’s) process

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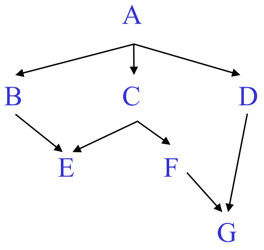
Implementation and Testing Order

How to code and test your design

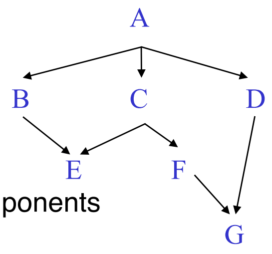
- You have a design and architecture
  - Need to code and test the system

- Key question, what to do when?

- Suppose the system has this module dependency diagram
  - In what order should you address the pieces?

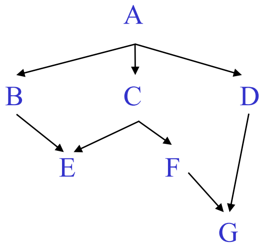


Bottom-up



- Implement/test children first
  - For example: G, E, B, F, C, D, A
- First, test G stand-alone (also E)
  - Generate test data
  - Construct test driver to run low-level components
- Next, implement/test B, F, C, D
- No longer unit testing: use lower-level modules
  - A test of module M tests:
    - whether M works, *and*
    - whether modules M calls behave as expected
  - When a failure occurs, many possible sources of defect
  - Integration testing is hard, irrespective of order

Top-down



- Implement/test parents (clients) first
  - Here, we start with A

- To run A, build *stubs* to simulate B, C, and D
  - Also known as mocking.
    - Tools: Mockito, PowerMock, ...

- Next, choose a successor module, e.g., B
  - Build a stub for E
  - Drive B using A

- Suppose C is next
  - Can we reuse the stub for E?

Implementing a stub or mock object

- Query a person at a console
  - Same drawbacks as using a person as a driver

- Print a message describing the call
  - Name of procedure and arguments
  - Fine if calling program does not need result
    - More common than you might think

- Provide "canned" or generated sequence of results
  - Often sufficient
  - Generate using criteria used to generate data for unit test
  - May need different stubs for different callers

- Provide a primitive (inefficient & incomplete) implementation
  - Best choice, if not too much work
  - Look-up table often works
  - Sometimes called "*mock objects*" (ignoring technical definitions?)

Comparing top-down and bottom-up

- Criteria
  - What kinds of errors are caught when?
  - How much integration is done at a time?
  - Distribution of testing time?
  - Amount of work?
  - What is working when (during the process)?

- Neither dominates
  - Useful to understand advantages/disadvantages of each
  - Helps you to design an appropriate mixed strategy

Catching design errors

- Top-down tests global decisions first
  - E.g., what system does
  - Most devastating place to be wrong
  - Good to find early

- Bottom-up uncovers efficiency problems earlier
  - Constraints often propagate downward
  - You may discover they can’t be met at lower levels

Amount of work

- Always need test harness

- Top-down
  - Build stubs but not drivers

- Bottom-up
  - Build drivers but not stubs

- Stubs are usually more work than drivers
  - Particularly true for data abstractions

- On average, top-down requires more non-deliverable code
  - Not necessarily bad

What components work, when?

- Bottom-up involves lots of invisible activity
  - 90% of code written and debugged
  - Yet little that can be demonstrated

- **Top-down depth-first**
  - Earlier completion of useful partial versions

Regression testing

- Ensure that things that used to work still do
  - Including performance
  - Whenever a change is made
- Knowing exactly when a bug is introduced is important
  - Keep old test results
  - Keep versions of code that match those results
  - Storage is cheap

Perspective…

- Software project management is challenging
  - There are still major disasters – projects that go way over budget, take much longer than planned, or are abandoned after large investments
  - We're better at it than we used to be, but not there yet (is "software engineering" real "engineering"?)
- Project management is a mix of hard and soft skills
- We've only skimmed the surface
  - Next: CSE 403, internship/real world, ???

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Bonus Material!

Download the slides in .pptx format to see material on “hidden slides” not presented in this quarter’s lecture. (Hidden slides not visible in PDF.)